Design of University Computer Experiment Platform Based on Mixed Mode in The Context of Information Technology Innovation

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Abstract. Under the backdrop of innovation in information technology application, experimental teaching plays a pivotal role in enhancing students' system design ability. Addressing the current issues in computer composition principle experiment teaching, a virtual-reality integrated experiment platform is developed based on cloud service architecture and B/S mode. The utilization of EDA (Electronic Design Automation) technology for designing virtual experiments not only enhances the intuitive nature of the experimental effect but also provides greater flexibility in experimental design, thereby fostering students' fundamental capability to tackle complex engineering problems. Furthermore, through the incorporation of FPGA (Field Programmable Gate Array) and CPLD (Complex Programmable Logic Device) technology, physical experiments are designed to facilitate the transition from computer usage to computer construction, thus cultivating students' independent and controllable ability for innovation in information technology application while effectively elevating the quality of experimental teaching.

Keywords: experimental platform, virtual experiment, field programmable gate array, electronic design automation.

1 Introduction

The essence of innovation in the application of information technology lies in achieving autonomous and controllable key core technologies [1]. The capability of computer systems is a crucial ability for addressing bottleneck technologies, and it is also an essential skill to be cultivated when training innovative talents in information technology at universities [2]. Computer system capability refers to the ability to consciously apply a systemic view, understand the holistic, interconnected, hierarchical, dynamic, and open nature of computer systems. It involves using systematic methods to master the mechanisms of hardware-software collaboration and interaction. Experimental teaching plays a pivotal role in enhancing system design capabilities.

Y. Feng et al. (eds.), *Proceedings of the 4th International Conference on Internet, Education and Information Technology (IEIT 2024)*, Atlantis Highlights in Social Sciences, Education and Humanities 26,
https://doi.org/10.2991/978-94-6463-574-4_24

Virtual experiment technology-based experimental platforms have wide-ranging applications across various disciplines for both research and teaching purposes. They hold promising prospects for practical use. Many domestic and international academic institutions have conducted research in this area [3]. For instance, MIT has developed a network-supported remote microelectronics laboratory that enables remote experimentation on the characteristics of microelectronic devices through client-server communication [4,5]. Similarly, NUS's Department of Electronic Engineering has established a virtual laboratory for frequency modulation experiments as part of their undergraduate course on communication principles. This virtual lab can be accessed via web browsers and employs data traffic reduction schemes while verifying users' access rights.

In terms of virtual experiment technology and virtual laboratory construction, China started relatively late compared to other countries; however, due to its promising application prospects within science and engineering education fields, extensive attention has been given to research efforts in this domain [6]. Notably, Peking University's Computer Science Department has developed a network-based virtual experiment platform aimed at assisting with experimental teaching related to computer system architecture courses. This platform includes experiments on pipeline operations as well as cache memory design exercises.

To address issues surrounding current computer organization & architecture experiment teachings particularly those pertaining student's systematic abilities we propose implementing B/S architecture based cloud service supported integrated Virtual Computer Organization & Architecture Experiment Platform (VCOAEP). By integrating resources such as experimental equipment cloud servers simulation software online courses etc., VCOAEP aims not only improve resource utilization but also achieve fine-grained management over assessment processes while promoting open sharing among different educational institutions thus providing robust support towards enhancing quality standards within this field ultimately yielding positive outcomes from our educational endeavors.

2 Design of Experimental Platform Based on Hybrid Model

In order to enhance the experimental experience, adapt to the experimental teaching activities under the background of the Internet, quantify the experimental process, and improve the utilization rate of experimental equipment, a "virtual and real combined" hybrid experimental teaching platform was constructed. The overall architecture of the experimental platform is shown in Fig. 1. Students enter the experimental management system through the browser and log in to the system after completing their student identity authentication. They can then download relevant plug-ins, learning materials, and complete experiment reservations, and subsequently conduct virtual simulation experiments or physical experiments. Before the experiment, teachers upload experimental cases, experimental teaching plans, experimental materials, and micro courses, etc. to the platform, and students can systematically preview the experiment objectives, experiment principles, operation procedures, and data processing methods by accessing the platform. In the middle of the experiment, teachers can guide students' experiments through the experimental data processing results provided by the platform and correct incorrect operations in time. In the post-experiment period, teachers can use the platform to review and correct students' experiment reports and complete the archiving of experimental data. The scientific and reasonable workflow of the virtual and real combined experimental platform can create a good user experience for students and improve the quality of engineering experiment courses.

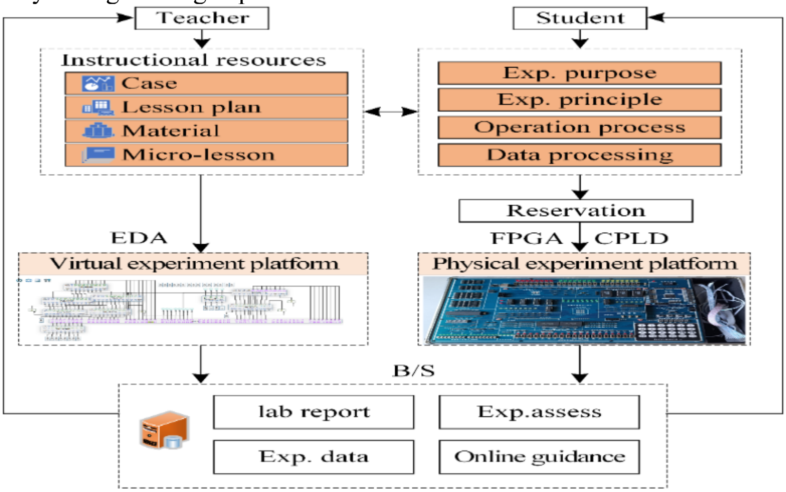

Fig. 1. Overall architecture of the experimental platform.

3 Design of Teaching Platform based on Virtual Experiment

The application of EDA technology in the experiment of computer organization principles is to use the online programmable characteristics of FPGA or CPLD to implement the required logic functions, such as the design of ALU, controller, instruction system, etc. The application of EDA technology not only familiarizes students with the basic composition and working principles of computers, but also improves their design ability of programmable logic devices. Moreover, the designed experimental system is reusable, which facilitates students to carry out comprehensive design experiments.

Using the virtual experiment of the arithmetic unit as an example, we illustrate the application of the virtual experimental teaching platform. In the B/S mode, one can directly enter the server address into the browser address bar to open the main interface.

(1) Circuit drawing. Click the "New" option on the File menu to perform a new operation. The main interface just opened is in the new file state by default, and you can directly create a circuit diagram in the workspace.

(2) Component generation. To generate the required experimental components in the workspace, simply drag the components from the toolbox to the workspace. There are 4 colors of chip pins, representing 4 different types of pins: black for default connected pins that do not require students to connect, such as ground and power pins; green for output pins; blue for input pins; and purple for input/output pins.

(3) Connection. When the mouse moves over the pin and the background color of the pin turns green, it indicates that you have entered the pin pull area. At this time, you can drag the mouse to draw a connection line. When you reach the target pin pull area, release the mouse, and the virtual experiment system will automatically generate a connection line between the two pins.

(4) Save. Click the "Save" option on the File menu. You can perform the save operation. Save all experimental content including connections in the existing workspace. This operation saves the circuit diagram to a text file, and clicking "Show in Folder" in the pop-up dialog box allows you to view the circuit file.

(5) Run. Click the "Power On" button on the toolbar to turn on the power. The design diagram and running effect diagram of the virtual experiment circuit for the computing unit are shown in Fig. 2.

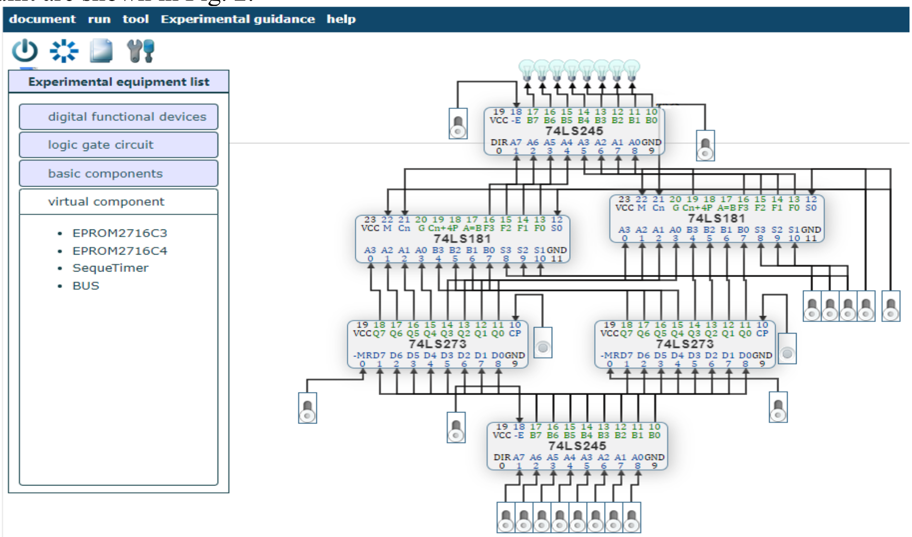

Fig. 2. Calculator virtual experiment circuit.

4 Design of Teaching Platform based on Real Experiment

Students master the basic principles and methods through virtual experiments, and can only conduct offline experiments after passing online tests and assessments. Offline experiments increase the difficulty, mainly focusing on comprehensive and design-oriented experiments, mainly cultivating students' ability to collaborate in designing software and hardware. Students make appointments for offline experiments in groups. The experiment box is equipped with programmable logic chips such as CPLD and FPGA, allowing students to visually see the experimental results on the experimental equipment. Taking the example of a computer-based experiment using reconfigurable principles, we illustrate the application of a physical experiment teaching platform.

(1) Open the Quartus II software and perform hardware settings. Use FPGA to implement the function of the arithmetic unit, CPLD to implement the functions of temporary storage 1, temporary storage 2, arithmetic unit, and three-state output gate, and EP1K10 to implement the function of the control circuit. The VHDL program for the arithmetic unit part of this experiment is as follows:

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use IEEE.STD_LOGIC_UNSIGNED.ALL;
entity reconst is
port(S:in std_logic_vector(3 downto 0);
    LDR1,LDR2,T4,ALU_G,M,CN:in std_logic;
    data:inout std_logic_vector(15 downto 0));
end reconst;
architecture doit of reconst is
signal data1,data2,data3:std_logic_vector(15 downto 0);
begin
P1:process(T4,LDR1)
begin
    if(T4'event and T4='1')then
        if(LDR1='1')then
            data1<=data;
        end if;
    end if;
end process P1;
P2:process(T4,LDR2)
begin
    if(T4'event and T4='1')then
        if(LDR2='1')then
            data2<=data;
        end if;
    end if;
end process P2;
data3<=data1 when S="0000" and M='0' and CN='1' else
    data2 when S="1010" and M='1' else
    data1+data2 when S="1001" and M='0' and CN='1' else
    data1+data2+1 when S="1001" and M='0' and CN='0' else
    "00000000";
data<=data3 when ALU_G='0' else "XXXXXXXX";
end doit;
```

(2) Download the program to the experiment box through the JTAG port on the bottom plate.

(3) Connect all wires according to the wiring diagram.

(4) Enter the experimental program and input the operation instruction. During the input process, you can press the "Cancel" button to make input modifications.

(5) Set the operation mode and configure parameters such as "S3S2S1S0MCn".

(6) After the mode setting is completed, press the "Confirm" button to enter the first set of data input state. The data input format is in hexadecimal format. During the input process, you can press the "Cancel" button to make modifications, and press the "Confirm" button to complete the input. Use the same operation to enter all data.

(7) The data bus display light shows the operation result.

According to the above method, use CPLD to reconstruct the adder, shift register circuit, register file circuit, program counter circuit, address register circuit, instruction register circuit, instruction decoder circuit, etc.

5 Conclusions

Combining virtual experiments with physical experiments, closely integrating experimental content with system design, and constructing a computer organization principle experimental platform based on a hybrid model. At the same time, a course assessment system is established, and students use online and offline time, centralized and decentralized venues in groups to flexibly conduct data collection, code debugging, algorithm design, and practical manipulation to complete the entire experimental course content. This platform can help students establish a concept of the whole machine, while also allowing students to feel the application of computer organization principle course content in computer systems, further cultivating students' enthusiasm and initiative to learn computer organization principle, and improving teaching effectiveness.

Acknowledgment

This work is supported by the Research Project of University Teaching Reform in Hunan Province (Xiangjiaotong [2023] 352, HNJG-20230884), the Hunan Province Basic Education Teaching Reform Research Project (Xiangjiaotong [2023] 316, Z2023154), "the 14th Five-Year Plan" Key Disciplines and Application-oriented Special Disciplines of Hunan Province (Xiangjiaotong [2022] 351).

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